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A Stockability Equation for Forest Land in Siskiyou County, California

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Abstract

An equation is presented that estimates the relative stocking capacity of forest land in Siskiyou County, California, from the amount of precipitation and the presence of significant indicator plants. The equation is a tool for identifying sites incapable of supporting normal stocking. Estimated relative stocking capacity may be used to discount normal yields to levels that these sites can produce.

Keywords: Stocking capacity, indicator plants, yield (forest), California, forest productivity.

Introduction

The prediction of potential timber yields requires an evaluation of stocking and productivity. Normal yield tables often are the only tools available. Where shallow soils, moisture stress, soil toxicity, or other limitations on stocking capacity are present, many sites are unable to support normal stocking and yields. For such areas, normal yield tables may overestimate stocking capacity and productivity.

MacLean and Bolsinger (1973) describe a procedure for estimating relative stocking capacity from equations based on site index and geographical and environmental variables, and from the presence of indicator plants. These estimates are used to identify sites incapable of supporting normal stocking and to discount normal yields given these limitations.

This paper presents an equation to estimate relative stocking capacity on forest land in Siskiyou County, northern California. The equation incorporates the assumptions and techniques developed by MacLean and Bolsinger.

Background

In 1969, the Forest Inventory and Analysis work unit of the Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, began to develop a technique to determine quantitatively the productive potential of forest land incapable of supporting normal yield table levels of stocking.[1] At that time, no documented technique was available to make such evaluations.

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[1] Unpublished study plan, 1969, "Study Plan for the Development of a Method for Estimating the Stocking Capacity of Forest Lands," by Robert B. Pope. On file at the U.S. Department of Agriculture, Forest Service, Forestry Sciences Laboratory, Forest Inventory and Analysis, P.O. Box 3890, Portland, Oregon 97208.

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Griffin (1967), in a study in northern California, developed a vegetative drought index relating soil moisture to the presence or absence of 172 indicator plants. Building on Griffin's work, MacLean and Bolsinger (1973) speculated that, because stand density is related to soil moisture, indicator plants also would be useful in estimating stocking capacity. In their study, stocking capacity is expressed by stand density index—an expression of relative stand density that permits direct comparison among stands in different stages of development (Reineke 1933).

MacLean and Bolsinger made three assumptions for their study. First, they accepted an assertion by Daubenmire and Daubenmire (1968) that plant species on a site tend to persist even after disturbance. Second, they accepted the advice of Waring and Majo (1964) to limit use of plant indicators to presence or absence, as plant coverage is likely to be influenced by disturbance. Finally, they assumed a one-to-one relationship between stocking capacity and yield capability for a given site index.

Equations for estimating stocking capacity in Shasta and Trinity Counties in Californi were published in 1973 (MacLean and Bolsinger 1973). An additional report (MacLea and Bolsinger 1974) presents equations for several other regions in California. Neithe publication provides an equation for Siskiyou County.

In 1981, the Forest Inventory and Analysis work unit began to develop an equation fo Siskiyou County based on the work of MacLean and Bolsinger (1973). The work unit needed this tool to identify stocking limitations on its permanent plots within the count in order to improve periodic inventory estimates. The equation presented in this pape is the result.

The Equation

The equation for Siskiyou County estimates the stocking capacity of a site expressed as a proportion of that for sites described in normal yield tables. For areas without stocking limitations, the equation estimates a relative stocking capacity that is within ±20 percent of "normal." This implies that a limitation on stocking exists whenever relative stockin capacity is less than 0.8 of normal. For such areas, normal yield predictions are discounted by the estimated relative stocking capacity. If, for example, the estimated relative stocking capacity of a Douglas-fir site is 0.5, then the normal yield table predictions of basal area, number of trees, and yield should be multiplied by 0.5.

The generalized form of the equation is:

$$\text{Relative stocking capacity} = f\,(\text{NSDI}, X_i).$$

Where: Relative stocking capacity is expressed as a proportion of normal yield stockin
NSDI = normal stand density index, and
X_i = precipitation or indicator plant variables.

The equation for Siskiyou County is:

$$\text{Relative stocking capacity} = \frac{1}{\text{NSDI}}(356 + 81X_1 + 0.0283X_2 - 80X_3 - 71X_4 - 53X_5 - 246X_6 - 80X_7 - 131X_8 - 76X_9 + 84X_{10} - 98X_{11} - 64X_{12} - 118X_{13} - 54X_{14}).$$

When: NSDI = normal stand density index from an appropriate yield table
X_1 = *Abies magnifica, Adenocaulon bicolor,* or *Smilacina* spp.[2]
X_2 = (annual precipitation)^2
X_3 = *Chrysothamnus* spp.
X_4 = *Quercus garryana*
X_5 = *Festuca* spp.
X_6 = *Pinus contorta* on a dry flat
X_7 = *Agropyron spicatum*
X_8 = *Lomatium nudicaule*
X_9 = *Arctostaphylos viscida*
X_{10} = *Salix* spp., except along streambeds and in low, wet areas
X_{11} = *Castilleja* spp.
X_{12} = *Juniperus occidentalis*
X_{13} = *Rhus trilobata*
X_{14} = *Artemisia tridentata*

The geographic area to which this equation applies is all of Siskiyou County except the area west of R. 11 W. (Mount Diablo Meridian) and the area of the Klamath Mountains north of the Siskiyou-Trinity County line and east of R. 12 W. (Mount Diablo Meridian). For this latter area, use the stockability equation for Shasta and Trinity Counties developed by MacLean and Bolsinger (1974).

Application

To use the equation, select a normal stand density index from a normal yield table that is appropriate for the site and species. Normal stand density indices (NSDIs) for yield tables commonly used in California are:

Species and source	NSDI
Ponderosa pine (Meyer 1961)	365
Douglas-fir (McArdle and others 1961)	370
Douglas-fir (Schumacher 1930)	400
Lodgepole pine (Dahms 1964)	460
Mixed conifer (Dunning and Reineke 1933)	479
White fir (Schumacher 1926)	565
California red fir (Schumacher 1928)	725

All other independent variables except annual precipitation have a value of one, if present, or zero, if absent. Annual precipitation is entered to the nearest inch.

The independent variable labeled "*Pinus contorta* on a dry flat" (variable X_6) should meet all of the following criteria to have a value of one:

1. Lodgepole pine is the only tree species present.
2. The stand occurs on a dry flat; pumice soil is usually present.
3. Topographic slope is 5 percent or less.

In Siskiyou County this combination is most common above 5,000 feet (1524 m) near Mount Shasta.

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[2] Scientific and common names of plants are given on page 5.

Several guidelines apply when determining which indicator plants are present. Search thoroughly to find plants that are typically scattered. Ignore plants growing within small areas that differ from the surrounding study area; examples are rock outcrops, springs, or skid roads. Elsewhere, tally all indicators even if scarce. Record the presence of indicator species that were obliterated by disturbance if this is known. The plant grouping of *Abies magnifica, Adenocaulon bicolor,* and *Smilacina* spp. (variable X_1) is recorded as present if any species within the group is found.

An Example

Can a hypothetical ponderosa pine site in Siskiyou County support normal stocking? If not, how is normal yield discounted to account for stockability problems?

Careful inspection of the site reveals the presence of four indicator plants: *Adenocaulon bicolor* (X_1), *Chrysothamnus* (X_3), *Festuca* (X_5), and *Agropyron spicatum* (X_7). *A. bicolor* is found at a spring and, because this locaiton is much wetter than the rest of the area, the presence of this plant is ignored. Also, a precipitation map indicates that the site annually receives 20 inches of water.

The appropriate values to insert into the equation are:

NSDI for ponderosa pine = 365;
annual precipitation = 20;
X_3, X_5, and X_7, = 1; and
all other plant indicators = 0.

Therefore:

$$\text{Relative stocking capacity} = \frac{1}{356}(356 + 0.0283(X_2)^2 - 80(X_3) - 53(X_5) - 80(X_7))$$

Entering values for NDSI, X_2, X_3, X_5, and X_7:

$$\text{Relative stocking capacity} = \frac{1}{356}(356 + 0.0283(20)^2 - 80(1) - 53(1) - 80(1)) = 0.42$$

Because the estimated relative stocking capacity is 0.42, the site is incapable of supporting a normal yield of ponderosa pine (relative stocking capacity is less than 0.8). To estimate the yield that the site can support at full stocking, multiply the normal yield for desired stand age by 0.42. Had the relative stocking capacity exceeded 0.8, the site would have been judged capable of supporting normal stocking and yield.

Reliability of the Equation

The relative stocking capacity is estimated by a ratio estimator. The numerator of this estimator is a linear equation that estimates the stand density index that the site will support. The denominator, an estimate of normal stand density index for the site, is selected from the appropriate normal yield table. The sampling error associated with the denominator is assumed to be zero (that is, the normal stand density index is assumed to be a constant). Descriptive statistics are presented only for the numerator.

The equation accounts for 83 percent of the variation (R^2) in stand density index capacity. The standard error of the estimate is 72 stand density index points. The equation was fitted by stepwise regression using the data from 70 plots within the study area.

Because stepwise regression analysis of large numbers of empirically selected variables may underestimate variance and overestimate the amount of explained variation when the number of observations is low, the equation was tested against the field data from 26 plots within the study area. This validation set was randomly selected from the entire set of study plots prior to the analysis. The validation plots were not used for model building. The standard deviation of the residuals computed for the validation set is 95 stand density index points. The difference between estimated and actual mean stand density indices is +7 stand density index points. This small amount of positive bias is probably an accident of sampling. This compares favorably with the range of bias, +6 to +21 stand density index points, observed by MacLean and Bolsinger (1973) while validating stocking equations for five other areas in California.

Plant Names

Scientific names	Common names
Abies concolor (Gord. & Glend.) Lindl. ex Hildebr.	white fir
Abies magnifica A. Murr.	California red fir
Adenocaulon bicolor Hook.	trail plant
Agropyron spicatum (Pursh) Scribn. & Sm.	wheatgrass
Arctostaphylos viscida Parry.	whiteleaf manzanitia
Artemsia tridentata Nutt.	big sagebrush
Castilleja spp. Mutis.	Indian paint-brush
Chrysothamnus spp. Nutt.	rabbitbrush
Festuca spp.	annual fescue
Juniperus occidentalis Hook.	western juniper
Lomatium nudicaule (Pursh) Coult. & Rose.	hog fennel
Pinus contorta Dougl. ex Loud.	lodgepole pine
Pinus ponderosa (Dougl. ex Laws.)	ponderosa pine
Pseudotsuga menziesii (Mirb.) Franco	Douglas-fir
Quercus garryana Dougl. ex Hook.	Oregon white oak
Rhus trilobata Nutt. ex T. & G.	squaw bush
Salix spp. L.	willow
Smilacina spp. De sf.	false solomon's seal

Names of trees are according to Little (1979); scientific names of grasses, herbs, and shrubs are according to Munz and Keck (1970).

Literature Cited

Dahms, Walter G. Gross and net yield tables for lodgepole pine. Res. Pap. PNW-8. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; **1964.** 14 p.

Daubenmire, R.; Daubenmire, Jean B. Forest vegetation of eastern Washington and northern Idaho. Tech. Bull. 60. Pullman, WA: Washington Agricultural Experiment Station; **1968.** 104 p.

Dunning, Duncan; Reineke, L.H. Preliminary yield tables for second-growth stands in the California pine region. Tech. Bull. 354. Washington, DC: U.S. Department of Agriculture; **1933.** 23 p.

Griffin, James R. Soil moisture and vegetation patterns in northern California forests. Res. Pap. PSW-46. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; **1967.** 23 p.

Little, Elbert L., Jr. Check list of United States trees (native and naturalized). Agric. Handb. 541. Washington, DC: U.S. Department of Agriculture; **1979.** 472 p.

MacLean, Colin D.; Bolsinger, Charles L. Estimating productivity of sites with a low stocking capacity. Res. Pap. PNW-152. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; **1973.** 18 p.

MacLean, Colin D.; Bolsinger, Charles L. Stockability equations for California forest land. Res. Note PNW-233. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment station; **1974.** 10 p.

McArdle, Richard E.; Meyer, W.H.; Bruce, D. The yield of Douglas-fir in the Pacific Northwest. Tech. Bull 201 (rev.). Washington, DC: U.S. Department of Agriculture; **1961.** 74 p.

Meyer, Walter H. Yield of even-aged stands of ponderosa pine. Tech. Bull. 630 (rev.). Washington, DC: U.S. Department of Agriculture; **1961.** 59 p.

Munz, Philip A.; Keck, David D. A California flora. Berkeley, CA: University of California Press; **1970.** 1,681 p.

Reineke, L.H. Perfecting a stand density index for even-aged forests. Journal of Agricultural Research. 46:627-638; **1933.**

Schumacher, Francis X. Yield, stand and volume tables for white fir in the California pine region. Bull. 407. Berkeley, CA: California Agricultural Experiment Station, University of California; **1926.** 26 p.

Schumacher, Francis X. Yield, stand and volume tables for red fir in California. Bull. 456. Berkeley, CA: California Agricultural Experiment Station, University of California; **1928.** 29 p.

Schumacher, Francis X. Yield, stand and volume tables for Douglas-fir in California. Bull. 491. Berkeley, CA: California Agricultural Experiment Station, University of California; **1930.** 41 p.

Waring, R.H.; Major, J. Some vegetation of the California coastal redwood region in relation to gradients of moisture, nutrients, light and temperature. Ecological Monographs. 34:167-215; **1964.**

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